



BWR Vessel and Internals Project Update

Drew Odell, Exelon
BWRVIP Integration Committee Technical Chairman
EPRI-NRC Technical Exchange Meetings
June 3-5, 2014

Overview Outline

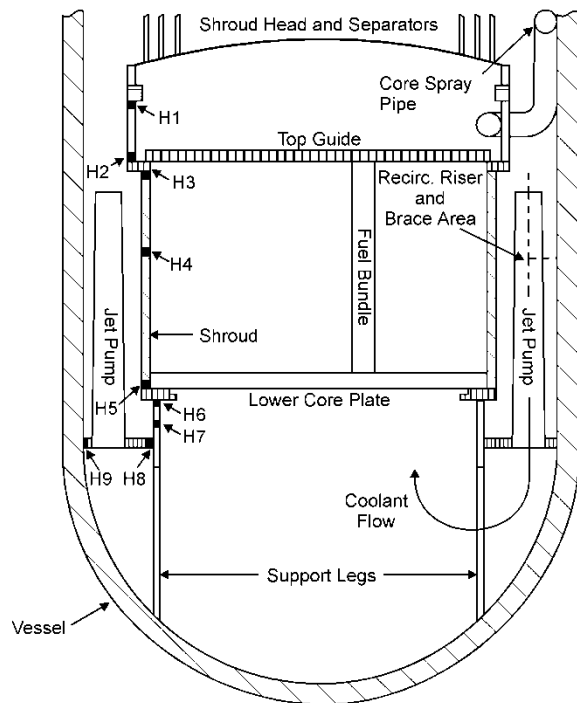
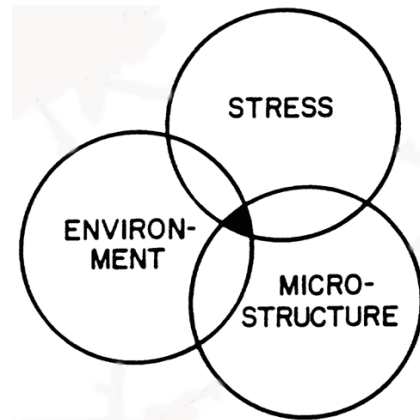
- Background
- Current Members and Organization
- BWRVIP Guidelines and Implementation
- Strategic Plan and Current Research Gaps
- BWRVIP Major Tasks
- Status of Key Topics with NRC
- Submittals to the NRC
- Contact Information



Background

Background

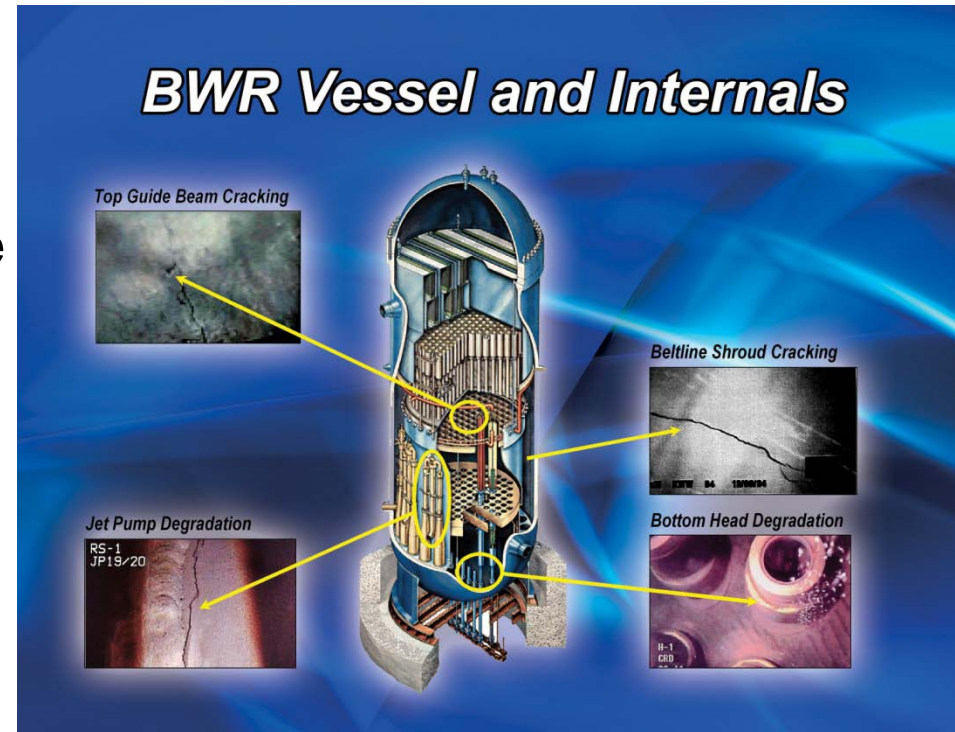
- Intergranular Stress Corrosion Cracking (IGSCC) in austenitic piping was a major issue for Boiling Water Reactors (BWRs) in the 1980s
 - susceptibility of reactor internals to IGSCC was also recognized



- Shroud cracking in 1993-1994 confirmed that IGSCC of internals is a significant issue for BWRs
- BWR utility executives formed the BWRVIP in mid-1994 to proactively address BWR reactor vessel and internals material condition issues
- The goal was to lead industry toward proactive generic resolution of vessel and internals material condition issues with generic, cost-effective strategies

BWRVIP Objectives

- Lead industry toward proactive generic resolution of vessel and internals material condition issues
- Identify or develop generic, cost-effective strategies from which each operating plant will select the alternative most appropriate to their needs
- Serve as a focal point for the regulatory interface with the industry in BWR vessel and internals material condition issues (including license renewal)
- Share information among members to obtain useful data from many sources



BWRVIP & NEI 03-08

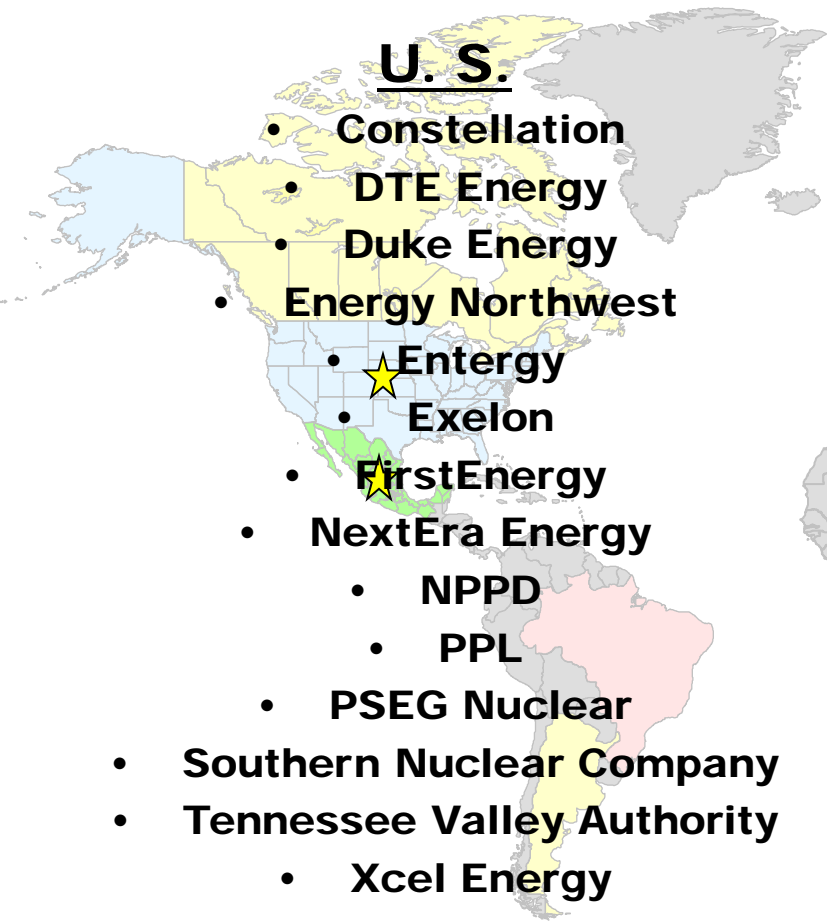
- In 2003, the industry established the NEI 03-08 Materials Initiative to pro-actively address Reactor Coolant System (RCS) materials issues in the United States for both PWRs and BWRs.
- The BWRVIP became one of six EPRI programs that was brought under the initiative. The six EPRI programs are:
 - Boiling Water Reactor Vessel and Internals Project
 - Materials Reliability Project (PWRs)
 - Nondestructive Examination
 - Steam Generators Project
 - Primary Systems Corrosion Research
 - Water Chemistry
- The implementation guidance for NEI 03-08 is largely patterned after the implementation guidance previously established by the BWRVIP.



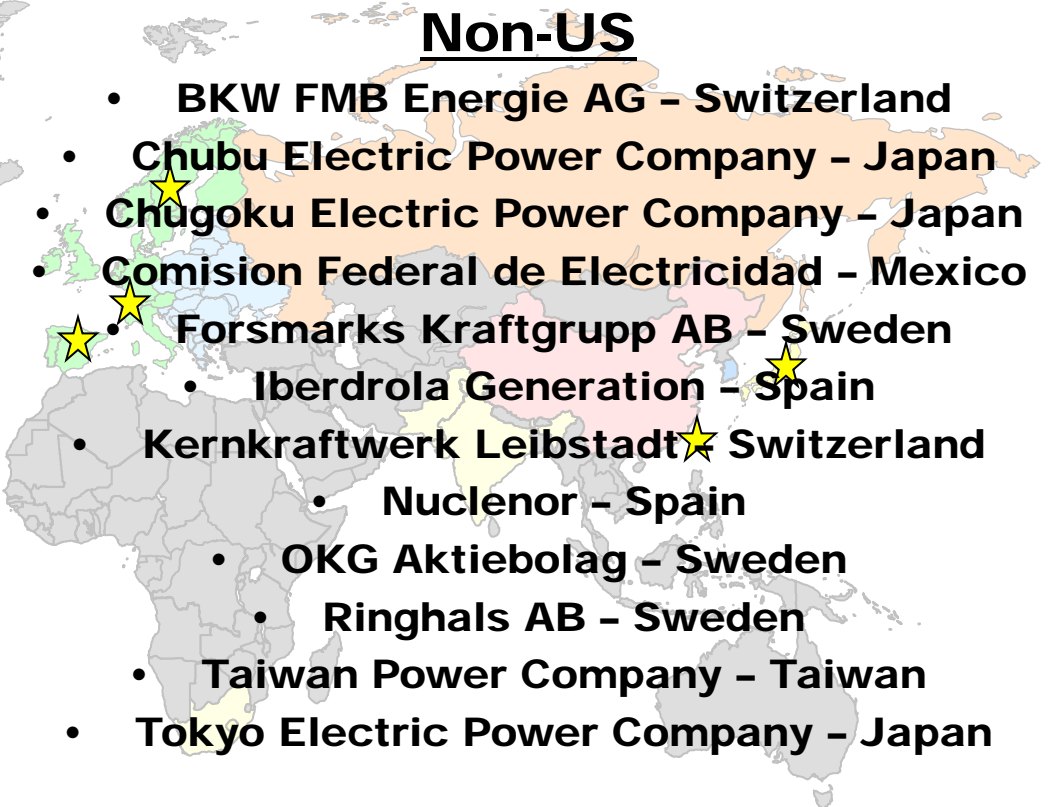
Current Members and Organization

2014 BWRVIP Member Utilities

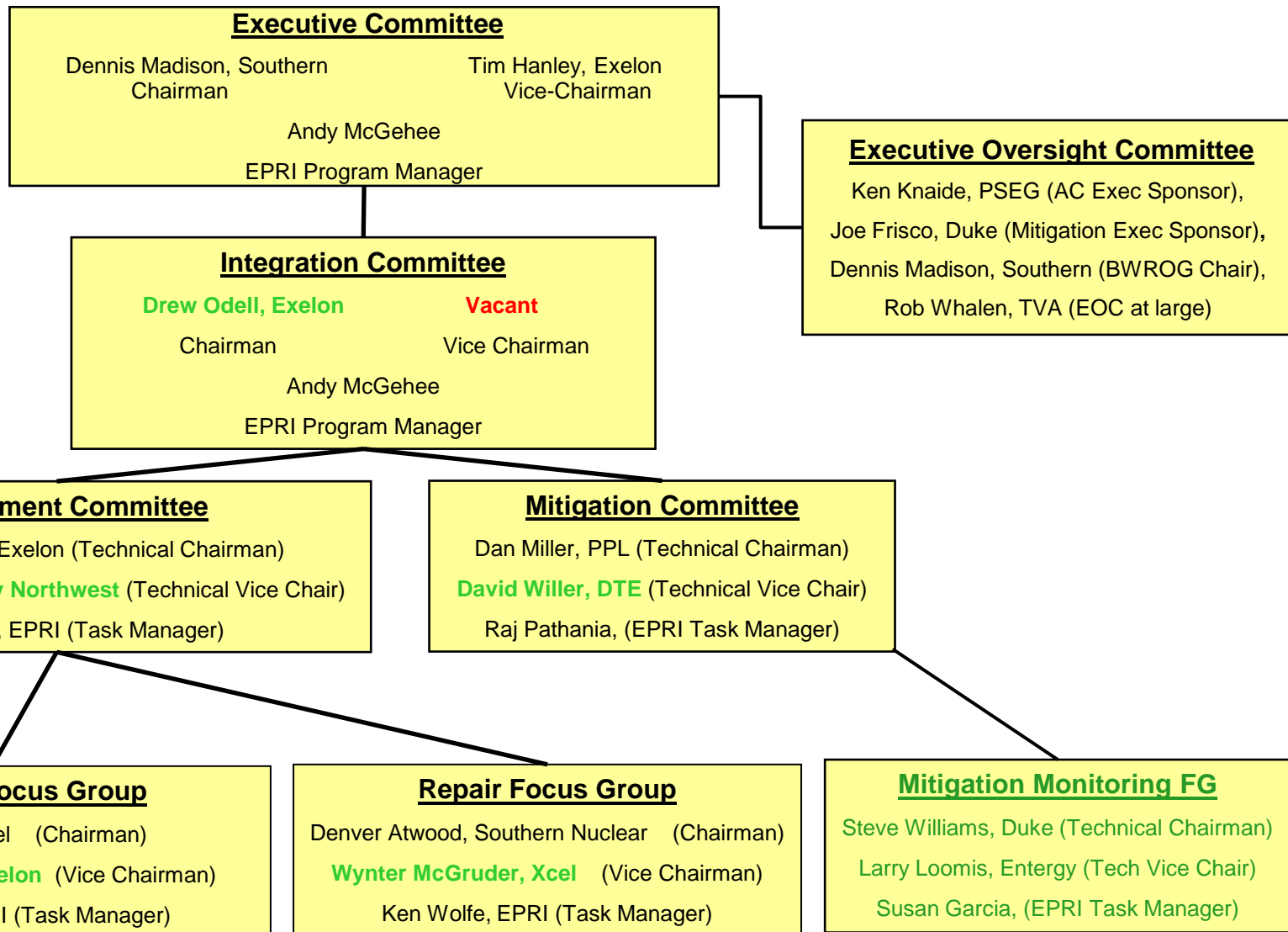
U. S.

- 
- Constellation
 - DTE Energy
 - Duke Energy
 - Energy Northwest
 - ★ Entergy
 - Exelon
 - ★ FirstEnergy
 - NextEra Energy
 - NPPD
 - PPL
 - PSEG Nuclear
 - Southern Nuclear Company
 - Tennessee Valley Authority
 - Xcel Energy

Non-US

- 
- BKW FMB Energie AG – Switzerland
 - Chubu Electric Power Company – Japan
 - ★ Chugoku Electric Power Company – Japan
 - Comision Federal de Electricidad – Mexico
 - ★ Forsmarks Kraftgrupp AB – Sweden
 - Iberdrola Generation – Spain
 - Kernkraftwerk Leibstadt ★ Switzerland
 - Nuclenor – Spain
 - OKG Aktiebolag – Sweden
 - Ringhals AB – Sweden
 - Taiwan Power Company – Taiwan
 - Tokyo Electric Power Company – Japan

2014 BWRVIP Organization



Technical Committee Responsibilities

- Assessment -- What needs to be inspected, when it needs to be inspected, inspection options, how to disposition observed degradation
- Inspection -- How to inspect, what equipment and techniques are available, what are the associated uncertainties
- Repair/replace -- What repair/replacement techniques are available and what are the associated requirements that must be met
- Mitigation -- How can SCC degradation be prevented or reduced



BWRVIP Guidelines and Implementation

BWRVIP Guidelines to Manage Degradation

<u>Component</u>	<u>Assessment (I&E) Guidelines</u>	<u>Inspection Guidelines</u>	<u>Repair/Replace Design Criteria</u>	<u>Mitigation Recommendations</u>
Core shroud	BWRVIP-76	BWRVIP-03	BWRVIP-02-A/-04-A	BWRVIP-62-A/-190
Core spray	BWRVIP-18-A	BWRVIP-03	BWRVIP-16-A/-19-A/-34	N/A
Shroud support	BWRVIP-38	BWRVIP-03	BWRVIP-52-A	BWRVIP-62-A/-190
Top Guide	BWRVIP-26-A	BWRVIP-03	BWRVIP-50-A	N/A
Core Plate	BWRVIP-25	BWRVIP-03	BWRVIP-50-A	BWRVIP-62-A/-190
SLC	BWRVIP-27-A	BWRVIP-03	BWRVIP-53-A	BWRVIP-62-A/-190
Jet pump assembly	BWRVIP-41	BWRVIP-03	BWRVIP-51-A	BWRVIP-62-A/-190
CRD guide/stub tube	BWRVIP-47-A	BWRVIP-03	BWRVIP-17/-55-A/-58-A	BWRVIP-62-A/-190
In-core housing/dry tube	BWRVIP-47-A	BWRVIP-03	BWRVIP-17/-55-A	BWRVIP-62-A/-190
Instrument penetrations	BWRVIP-49-A	BWRVIP-03	BWRVIP-57-A	BWRVIP-62-A/-190
LPCI coupling	BWRVIP-42-A	BWRVIP-03	BWRVIP-56-A	N/A
Vessel ID brackets	BWRVIP-48-A	BWRVIP-03	BWRVIP-52-A	BWRVIP-62-A/-190
Reactor pressure vessel	BWRVIP-74-A	N/A	N/A	N/A
Primary system piping	BWRVIP-75-A	N/A	N/A	BWRVIP-62-A/-190
Steam dryer	BWRVIP-139-A	BWRVIP-03	BWRVIP-181-A	N/A
Access hole cover	BWRVIP-180	BWRVIP-03	TBD	BWRVIP-62-A/-190
Top guide grid beam	BWRVIP-183	BWRVIP-03	BWRVIP-50-A	N/A
Bottom head drain line	BWRVIP-205	N/A	BWRVIP-208	N/A

Utility Implementation of BWRVIP Guidelines

- Utilities have committed to implement BWRVIP guidelines:
 - BWRVIP letters to NRC
 - Consistent with Nuclear Energy Institute (NEI) 03-08 Guideline for Management of Materials Issues
- BWRVIP-94 establishes framework for implementing BWRVIP guidance:
 - Requires that utilities develop/strengthen their inspection programs consistent with BWRVIP guidelines
 - Implement BWRVIP guidelines (as approved by Executive Committee) within two refueling outages
 - Deviations from BWRVIP guidelines require a NEI 03-08 deviation disposition (i.e., Executive level approved technical justification)
 - Notify NRC within 45 days of deviations from NRC-approved guidelines



Strategic Plan and Current Research Gaps

NEI 03-08 Integrated Materials Issues Strategic Plan

- Provides Systematic Approach to Managing Materials Issues
 - Identify vulnerabilities
 - Assess condition (inspect & evaluate)
 - Mitigate degradation initiation and propagation mechanism
 - Repair or replace as required
- Approach Used:
 - Degradation Matrix and Issue Management Tables
 - Degradation Matrix and Issues Management Tables to be maintained as living documents with periodic updates

Issue Management Tables

- BWRVIP Prepares the BWR Issue Management Tables (IMTs)
 - Initial version utilized BWRVIP-06, Safety Assessment
 - Identifies and prioritizes “gaps”
 - Information reflects current state of the BWRVIP Program
 - First published as BWRVIP-167 in March 2007 and then updated 2 to 3 years thereafter
 - Current version is BWRVIP-167NP, Revision 3, published in 2013

Current IMT High Priority Gaps (as of 3/23/2014)

GAP	Description	2014 BWRVIP Tasks () = Unfunded	2015 BWRVIP Tasks () = Unfunded
B-AS-07	Environmental Effects on Fatigue Resistance: Pressure Boundary Components [LTO - Direct]	(2.11), 2.31	(2.11), 2.31
B-AS-09	Assess the Impact of High Fluence on Fracture Toughness [LTO - Indirect]	2.7, 2.34	2.7, 2.34
B-AS-10	Assess the Impact of High Fluence and HWC Mitigation Technologies on SCC Crack Growth Rates [LTO - Indirect]	2.5, 2.6	2.5, 2.6, (2.39)
B-AS-18	Jet Pump Degradation Management	2.17	2.17
B-AS-26	High Strength Alloys [LTO - Indirect]	2.15	2.15
B-AS-32	Assessment of Core Plate Rim Hold Down Bolts	2.18	2.18
B-MT-02	ECP Measurement, Estimation, and Validation		(3.19), (3.20)
B-MT-04	On-Line NMCA Deposition Effectiveness and Implementation	3.1, 3.5, 3.14, (3.15), 3.17, 3.18	3.1, 3.5, 3.14, (3.15), 3.17, (3.19), (3.20), (3.21), (3.22)
B-MT-05	Water Chemistry Optimization for Power Operation, Startup and Shutdown	3.1, 3.10	3.1, 3.10
B-I&E-03	Inspection of Shroud & Shroud Support Weld Locations	2.27	2.27
B-RR-02	Welding Processes for Repair of Irradiated Material [LTO - indirect]	2.21	2.21
B-RG-05	Evaluation of Remote EVT-1	2.27, 2.28	2.27, 2.28
B-RG-09	Management of License Renewal Issues [LTO - Indirect]	Many	Many

Current IMT Medium Priority Gaps (as of 3/23/2014)

GAP	Description	2014 BWRVIP Tasks () = Unfunded	2015 BWRVIP Tasks () = Unfunded
B-DM-06	Environmental Effects on Fracture Resistance		
B-DM-07	Chloride Transient Effects on Low Alloy Steel Crack Growth Rates	3.10, (2.36)	3.10, (2.36)
B-AS-05	Assess Neutron Dose Rate Effects on Embrittlement of C&LAS [LTO - Indirect]	DOE	DOE
B-AS-11	Assess Non BWR Reactor Irradiated Materials Data Applicability to the BWR Environment [LTO - Indirect]	2.6	2.6
B-AS-15	FIV and High Cycle Fatigue Assessment: Reactor Internals		
B-AS-22	High-Cycle Thermal Fatigue: Piping Locations	(2.12)	(2.12)
B-AS-27	Alloy 182 / Creviced Alloy 600 SCC Susceptibility & Irradiation Effects [LTO - Indirect]		
B-AS-28	Impact of BWR Nozzle Penetrations on Pressure-Temperature Limit Curves [LTO - Indirect]		
B-AS-30	Material Surveillance Program Implementation for 80-Year Service Lives [LTO - Direct]	(2.38)	(2.38)
B-AS-33	Equivalent Margins Analysis for BWR Nozzles [new gap] [LTO - Direct]	(2.35)	(2.35)
B-MT-01	Alternative Mitigation Technologies	(2.24), MRP	(2.24), MRP
B-I&E-01	Inspection of Core Plate Rim Hold Down Bolts	2.18	2.18
B-I&E-02	Inspection of Hidden Weld Locations (Thermal Sleeves & Piping)	2.27	2.27
B-RR-05	Alternate High-Strength Materials	PSCR, ARRM	PSCR, ARRM
B-RR-08	Availability of Laser Welding for Repairs to Highly Irradiated Components [LTO - indirect]	2.21	2.21
B-RG-08	Reactor Pressure Vessel Material Surveillance Program Implementation for 80-Year Service Lives [LTO - Direct]	(2.38)	(2.38)
B-RG-10	R.G. 1.161 and ASME Section XI Appendix K Stress Intensity Factor Equation Non-conservatism [new gap]		

Current IMT Low Priority Gaps (as of 3/23/2014)

GAP	Description	2014 BWRVIP Tasks () = Unfunded	2015 BWRVIP Tasks () = Unfunded
<u>B-DM-03</u>	Low Temperature Crack Propagation	PSCR	PSCR
<u>B-DM-08</u>	Long-Term Neutron Fluence Effect on Low Alloy Steel Cracking Susceptibility [LTO - Indirect]		
<u>B-DM-09</u>	Long-Term SCC Susceptibility (Late Life SCC Initiation) [LTO - Indirect]		
<u>B-AS-12</u>	Thermal & Irradiation Embrittlement: Synergistic Effects (on CASS BWR Reactor Internals) [LTO - Indirect]		
<u>B-AS-14</u>	Environmental Effects on Fatigue Resistance: Reactor Internals [LTO - Direct]	2.31	2.31
<u>B-AS-20</u>	Assess Non-Safety Locations		
<u>B-AS-29</u>	Steam Dryer Evaluation Methodology (See Note)	(2.8) See Note	(2.8)
<u>B-AS-31</u>	BWRVIP-47-A (CRGT) Re-Inspection Requirements		
<u>B-I&E-06</u>	NDE Capability: CASS Components	NDEC	NDEC
<u>B-I&E-08</u>	Inspection and Evaluation Guidance for Repairs		
<u>B-I&E-09</u>	Examination Techniques for Detection of Loss of Preload in Reactor Internals Components		

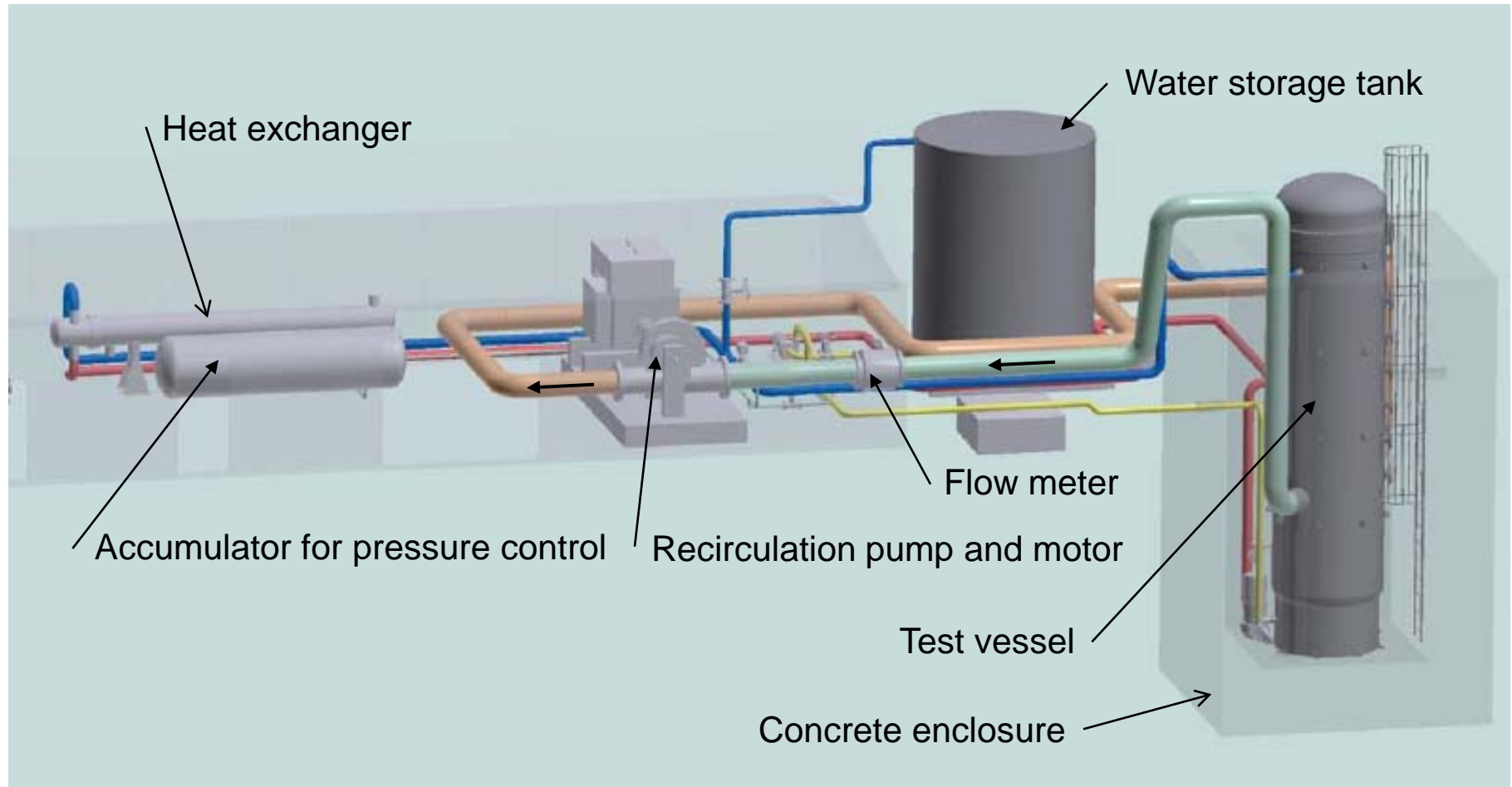


2014 BWRVIP Major Tasks

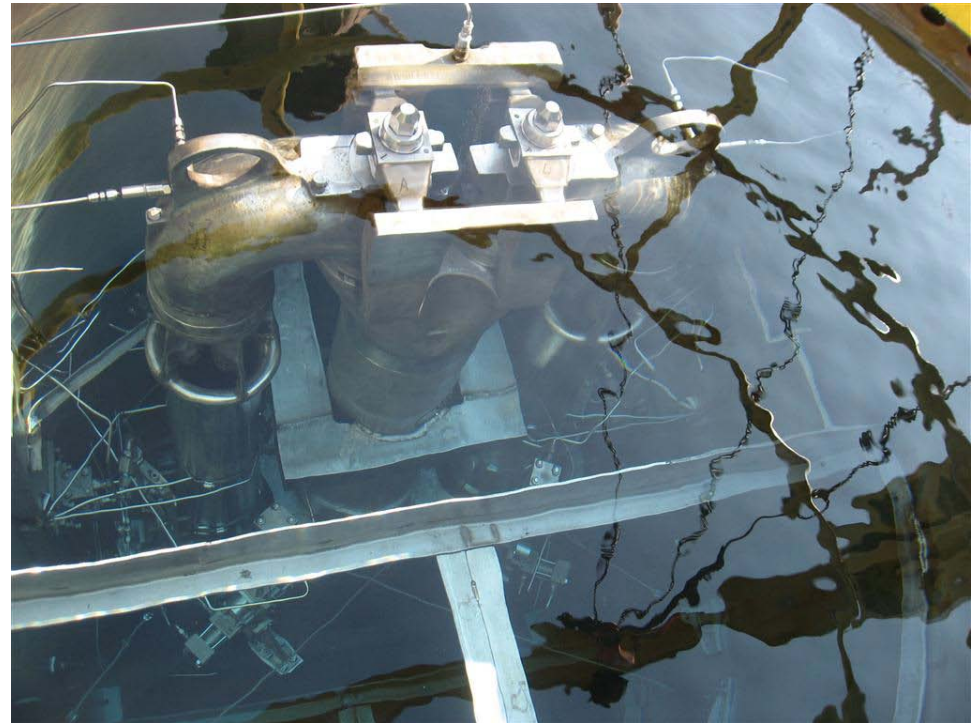
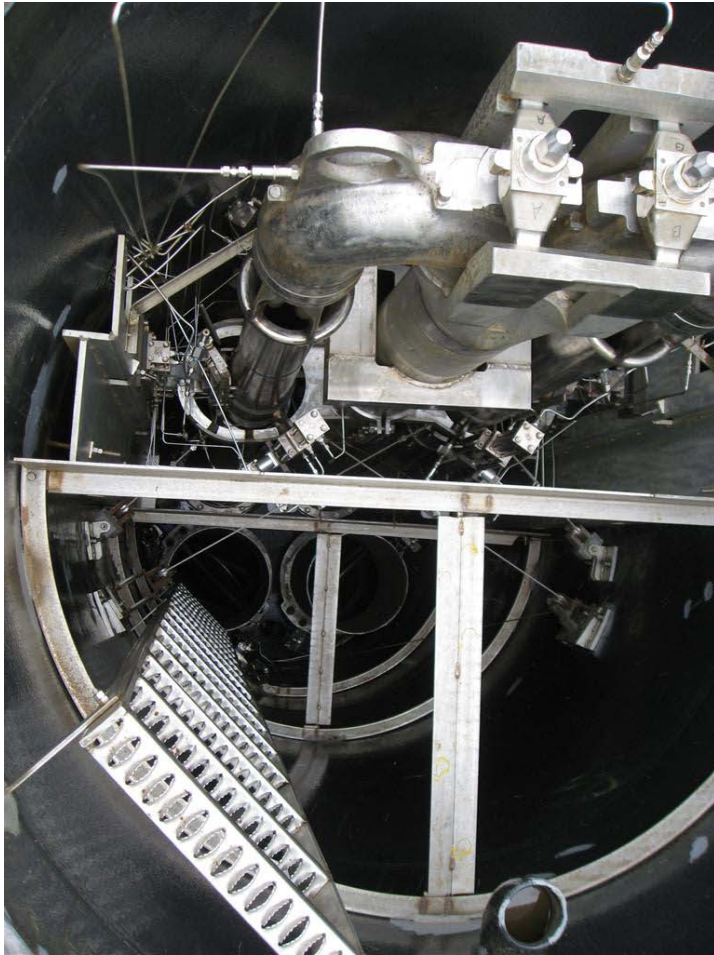
2014 BWRVIP Major Tasks

- 2014 Water Chemistry Guidelines Revision
 - Revision to the current BWR Water Chemistry Guidelines, BWRVIP-190
- Evaluation of Shroud Cracking (NDE & Boar Sample Analysis at a BWR-4)
 - This topic will be presented later during the Technical exchange meeting.
- Inspection and Evaluation Guidelines Optimization
 - Core Spray and Jet Pump Guidelines, currently Core Spray has been submitted to NRC and Jet Pump is in-progress
- Address Jet Pump Flow Induced Vibration Issues
 - See following slides for an update on the BWRVIP's Full Scale Jet Pump Test Facility

Full Scale Jet Pump Test Facility



View from Top of Pressure Vessel



Filled with water

Status of Full Scale Jet Pump Testing

- Testing of the facility in the BWR/5 jet pump configuration was completed in early Fall of 2012 and demonstrated that the test facility met all flow, temperature and pressure requirements, and was able to replicate the flow induced vibration (FIV) phenomena. The testing provided a significant amount of knowledge regarding the causes of jet pump FIV.
- Vendor demonstrations for FIV repair hardware have been performed.
- Vendors and utilities have used the facility for hardware developmental testing.
- Currently reconfiguration of the test facility for BWR/4 testing is underway.



Status of Key NRC Topics

Status of Key Topics with NRC

- Remote VT Round Robin
- Optimization projects - Core Spray, Jet Pumps, Shroud
- BWRVIP-62, Rev 1 - Inspection Relief with OLNC & HWC
- BWRVIP-234 - Evaluation of CASS in BWR Internals
- Integrated Surveillance Program (ISP) for BWRs

Involvement in Industry Wide Projects

- Remote VT Round Robin
 - BWRVIP co-funds the project
 - The BWRVIP Inspection Focus Group Chairman also Chairs the utility Ad hoc committee overseeing the project
 - There is extensive use of remote VT by the BWRVIP Inspection & Evaluation Guidelines (I&EGs) so the BWRVIP is a major stakeholder in the project
 - Objective and planning meeting (Phase 3) is scheduled for August 5 & 6, 2014 in Charlotte. NRC and PNNL are invited.

Optimization of BWRVIP I&E Guidelines

- Optimization Projects & Submittal Plans
 - BWRVIP is optimizing its I&EGs based on almost two decades of inspection history, lessons learned, and new information
 - The first three I&EGs to be optimized are Core Spray (BWRVIP-18), Jet Pump (BWRVIP-41) and Core Shroud (BWRVIP-76)
 - The optimized version of the Core Spray I&EG, BWRVIP-18, Rev 2, was submitted to the NRC in May of 2012. Response to NRC Request for Additional Information (RAI) was accomplished in April 2014. Final SE is targeted for early 2015.
 - The optimized version of the Jet Pump I&EG (BWRVIP-41) is complete and will be submitted in 2014 as agreed to with the Staff.

Topical Report Reviews

- BWRVIP-62, Rev 1 (Inspection Relief with OLNC & HWC)
 - Submitted to the NRC March 7, 2012
 - NRC requested review of many of the reference documents for BWRVIP-62, Rev 1
 - NRC questioned aspects of the already approved technology for classic Noble Metals Chemical Addition (NMCA) and Hydrogen Water Chemistry (HWC)
 - Good communications between Industry and Staff with several teleconference and a face-to-face meeting (March 28, 2013) held to outline the issues and work toward resolution
 - RAIs received from the staff in March 2014.
 - The BWRVIP is working on RAI responses with a pre-RAI submittal meeting with the staff scheduled for July 18, 2014.

Topical Report Reviews Cont.

- BWRVIP-234 (Evaluation of CASS in BWR Internals)
 - Technical report submitted to the NRC in September 2010
 - 1st RAI was received in September 2011 and response provided in September 2012.
 - NRC was headed towards issuance of SE with conditions and limitations related to screening criteria for evaluation of combined effects of thermal embrittlement and irradiation
 - Based on discussions with BWRVIP, NRC agreed to issue a 2nd RAI (April 2013)
 - May 21, 2013 meeting with industry (MRP and BWRVIP) and the Staff to discuss issues related to evaluation of CASS
 - BWRVIP and MRP have produced an industry proposed methodology which was submitted with BWRVIP-234's RAI response. Submitted to the NRC on May 23, 2014.

Integrated Surveillance Program (ISP) for BWRs

- Due to the BWRVIP's capsule testing process, including BWRVIP Committee review and approval of the capsule reports, the capsule reports cannot be completed within one-year and thus extensions to 18 months are necessary.
- Historically, the BWRVIP provided notification letters for the delays, but in recent years submitted formal extension requests for the last three ISP capsule withdrawals (Susquehanna 1, Duane Arnold and Perry).
- A conversation was held with the NRC in November 2013 and the NRC noted that the SE for the ISP acknowledges the BWRVIP as being responsible for submittal of ISP capsule reports and, if needed, extension requests.

Integrated Surveillance Program (ISP) for BWRs

- The NRC asked that extension requests include the current Effective Full Power Years (EFPY) for the plants affected by the capsule results and the EFPY for the approved P-T curves at those plants. The BWRVIP agreed to include that information in future requests and provided that information to the NRC for Duane Arnold and Perry via letter 2013-211, dated 11/20/13.
- Several communications with the staff have followed to ensure all technical information was available for the staff to complete their review.
- It is expected that the staff will provide responses to the extension requests shortly.



Submittals to the NRC

Topical Report Reviews

Recent Safety Evaluations or Approvals of “-A” Reports

- BWRVIP-158-A, Flaw Proximity Rules (Final 02/01/13)
- BWRVIP-173-A, Evaluation of Chemistry Data for BWR Vessel Nozzle Forging Materials (Final 02/01/13)
- BWRVIP-241, Probabilistic Fracture Mechanics Evaluation for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii (Final 04/19/13)
- BWRVIP-18, Revision 1-A, Core Spray Inspection & Evaluation Guidelines (Final 05/02/13)
- BWRVIP-138, Revision 1-A, Jet Pump Beam Inspection & Evaluation Guidelines (Final 07/24/13)
- BWRVIP-86, Revision 1-A, Integrated Surveillance Program (Final 03/26/14)

Topical Report Reviews

Submittals for Review and Approval that are Still in Process

- BWRVIP-183, Top Guide Grid Beam Inspection and Evaluation Guidelines, Submitted 01/15/2008 (in BWRVIP's house to address conditions in draft SE)
- BWRVIP-234, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels for BWR Internals, Submitted 9/10/2010 (in NRC's house for Final SE)
- BWRVIP-76, Revision 1, Core Shroud Inspection and Evaluation Guidelines, Submitted 06/30/2011 (in NRC's house for Final SE)
- BWRVIP-100, Revision 1, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds, Submitted 02/07/2012 (in BWRVIP's house for RAI response)
- BWRVIP-62, Revision 1, Technical Basis for HWC Inspection Relief, Including OLNC, Submitted 03/07/2012 (in BWRVIP's house for RAI response)
- BWRVIP-18, Revision 2, Optimized Core Spray Inspection and Evaluation Guidelines, Submitted 05/09/2012 (in NRC's house for final SE)
- BWRVIP-42, Revision 1, Low Pressure Core Injection Coupling Inspection and Evaluation Guidelines, Submitted 11/06/2012 (in BWRVIP's house for RAI response)
- BWRVIP-84, Revision 2, Guidelines For Selection and Use of Materials for Repairs to BWR Internal Components, Submitted 03/13/2013 (in BWRVIP's house for RAI response)
- BWRVIP-139-A License Renewal Appendix, LR Appendix for Steam Dryer Inspection and Evaluation Guidelines, Submitted 02/21/2014 (in NRC's house for initial review)

Topical Report Reviews

Safety Evaluations Expected in the Near Term

- BWRVIP-76, Revision 1, Core Shroud I&E Guidelines
 - RAI response provided to NRC on 4/3/2014
- BWRVIP-18, Revision 2, Core Spray Inspection & Evaluation Guidelines
 - RAI response provided to NRC on 4/10/2014
- BWRVIP-234, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels for BWR Internals
 - RAI response provided to NRC May 23, 2014.

Topical Report Reviews

Recent Submittal for Information Only

- BWRVIP-167NP, Revision 3: BWR Vessel and Internals Project, BWR Issue Management Tables (09/30/2013)
- BWRVIP-275NP, BWR Vessel and Internals Project, Testing and Evaluation of the Susquehanna Unit 1 120° Capsule (10/24/2013)
- BWRVIP-03, Revision 16 RPV and Internals Examination Guidelines (03/18/2014)
- BWRVIP-279NP, BWR Vessel and Internals Project, Testing and Evaluation of the Duane Arnold 108° Capsule (4/28/2014)

Topical Report Reviews

Near Term Submittals

- BWRVIP-41, Revision 4, Jet Pump Assembly Inspection and Evaluation Guidelines (this is the “Optimized” version of the jet pump I&E guidelines)
- BWRVIP-181, Revision 1, Steam Dryer Repair Design Criteria
- BWRVIP-76, Revision 2, Core Shroud Inspection and Evaluation Guidelines (this is the “Optimized” version of the core shroud I&E guidelines)
- BWRVIP-25, Revision 1, Core Plate Inspection and Evaluation Guidelines
- “-A” versions of BWRVIP-108, Technical Basis for the Reduction of Inspection Requirements for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii, and companion report BWRVIP-241, Probabilistic Fracture Mechanics Evaluation for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii

BWRVIP Contact Information

- Drew Odell – Utility Technical Chairman .
610-765-5483 (w), 610-212-1155 (c), andrew.odell@exeloncorp.com
- EPRI BWRVIP Team
 - Program Manager: Andy McGehee 704-502-6440
amcgehee@epri.com
 - Inspection: Jeff Landrum 704-595-2553
 - Assessment: Bob Carter 704-595-2519
 - Repair: Ken Wolfe 650-855-2141
 - Mitigation: Raj Pathania 650-855-8762
- Chuck Wirtz 440-346-7124 (BWRVIP-NRC interaction support)
- Robin Dyle 205-426-5371 (MAPC –NRC interaction support)
- Amardeep Mehat 650-855-2046 (General BWRVIP Communication support)

Together...Shaping the Future of Electricity

Background Information

- Additional slides follow if needed.